FOOD AND FEEDING BEHAVIOUR OF THE GREAT INDIAN BUSTARD *ARDEOTIS NIGRICEPS* (VIGORS) [1]

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(With two plates and four text-figures)

INTRODUCTION

The great Indian bustard *Ardeotis nigriceps*, endemic to parts of the Indian subcontinent, is an endangered avian species. It is included in Schedule I of the Wildlife (Protection) Act, 1972, and a number of sanctuaries have been established for its protection (Rahmani 1987, 1989). The present study on the food and feeding behaviour of the species forms part of a wider investigation on its ecology. Studies on food and feeding behaviour were mainly done at Karera Bustard Sanctuary, Madhya Pradesh, but wherever necessary, data from other sites such as Nanaj bustard area in Solapur district, Maharashtra, and Rollapadu Bustard Sanctuary in Kurnool district, Andhra Pradesh, are also included.

Owing to its status as a game bird, the natural history of the great Indian bustard, including its food, has been described by many workers; but there is no detailed study on its feeding behaviour and seasonal dependence on different food items. This paper deals with these aspects. The study is based largely on faecal analysis. While previous reviews of food habits analyses (Hartley 1948, Van Tyne and Berger 1959, Korschgen 1969, Lorin 1970) maintain that analysis of faecal matter should be the last alternative for study, they also accept that it is the only solution where endangered species are concerned.

STUDY AREA

The 202.21 sq. km Karera Bustard Sanctuary (25°30' to 24°40'N, 78°5' to 78°12' E) (henceforth Karera) is located in Shivpuri district, Madhya Pradesh. The average annual rainfall recorded by us from 1983 to 1985 was 966 mm. Summers (March to June) are very hot (maximum recorded 48°C), but temperatures as low as 4° C have been recorded in winter (November to February). The terrain is gently undulating, with scattered stones and boulders.

The original vegetation of the area was classified as Tropical Dry Deciduous Forest (Champion and Seth 1968). There are a few hillocks, which some decades ago would have been covered with *Anogeissus pendula* trees, but indiscriminate cutting and lopping have eroded the hills, leaving stunted specimens. The plains have degraded into open scrub. Wherever possible, the land has been cultivated. Today the shrubs *Zizyphus rotundifolia* and *Acacia leucophloea* are the dominant natural plants, the latter scattered and the former in clumps in all the uncultivated parts of the plains.

In the scrub area, along with *Zizyphus*, various grasses were found but severely exploited by livestock. Except for private fields, the entire area was totally grazed. Among grasses *Heteropogon contortus, Cynodon dactylon, Andropogon pumilus, Pennisetum pedicellatum, Aristida* spp. and *Eragrostris* spp. were common.

A number of ephemeral streams run across the sanctuary and flow into the village tanks or rivers. These streams dry up by the end of September or October. With constant soil erosion in the hills, the dried stream beds show presence of soil, gravel and rocks all along their course.

There are 33 villages within the boundary of the Sanctuary, and both human density (127 persons/sq. km) and the livestock population (179.5/sq. km) are high.

The bustards are found in open scrubland. During our study period, there were about 25 bustards in the Sanctuary. The breeding season at

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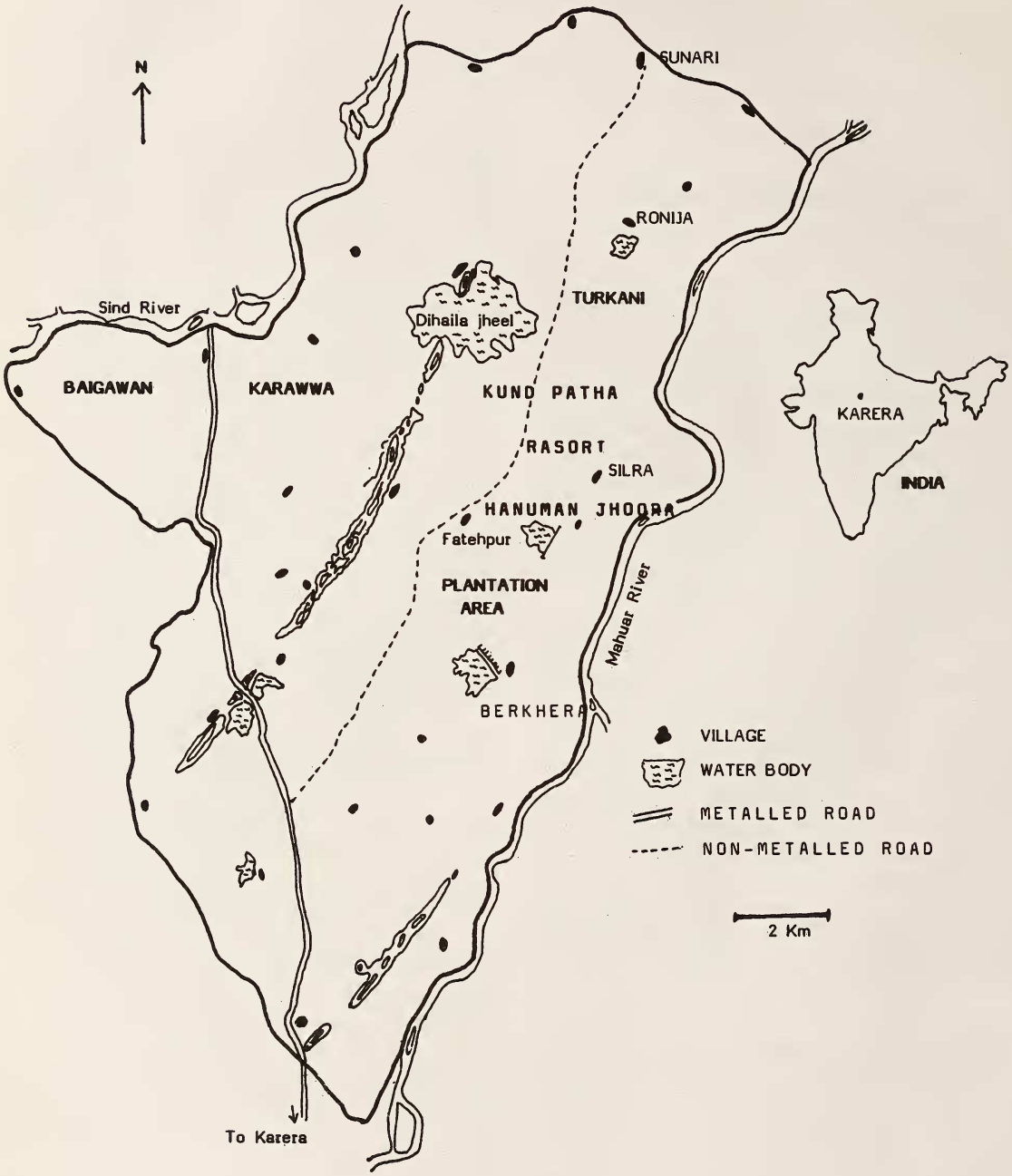
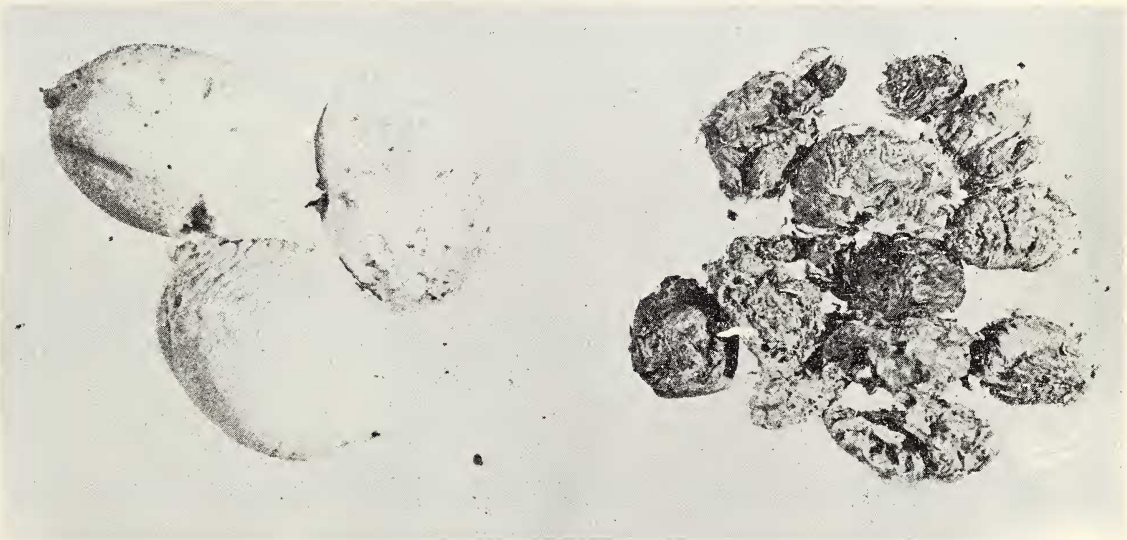


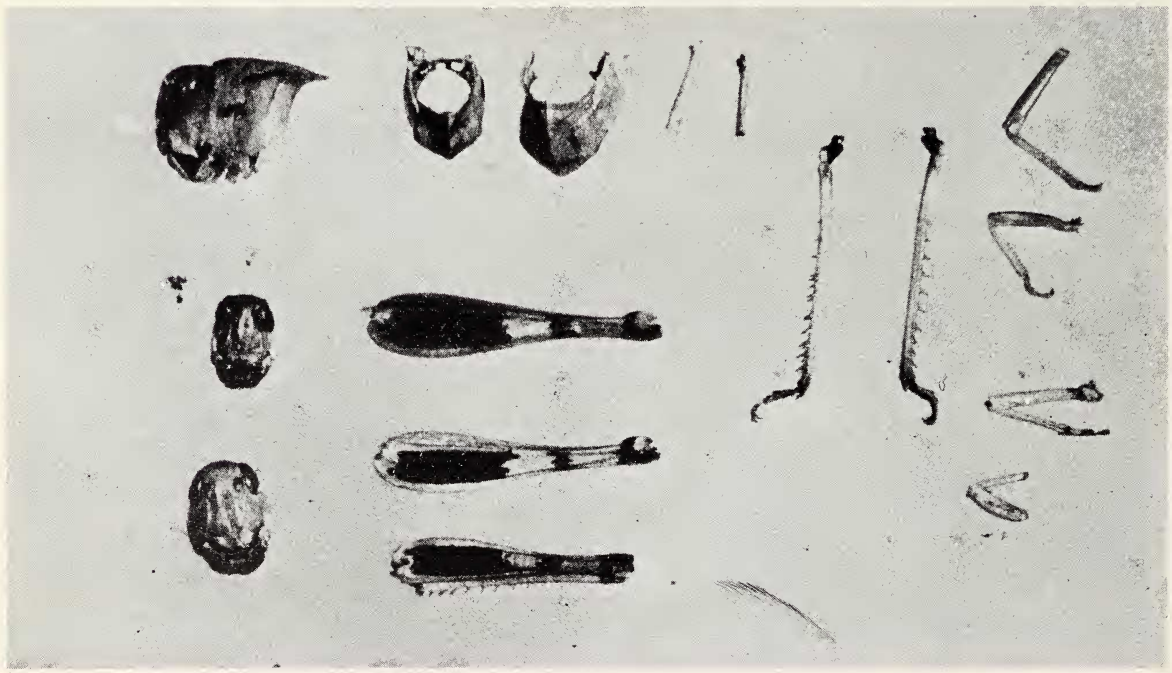
Fig. 1. Study area in the Great Indian Bustard Sanctuary, Karera.

Chana *Cicer arietinum* plant matter recovered from bustard faeces. *Left:* whole shredded and fibrous pod material. *Right above:* whole seeds. *Right below:* shredded and fibrous stalk material.



Mantid cacoons *(right)* after recovery from faecal matter, as compared to their shape before being eaten *(left)*.

Coleopteran body parts recovered from faecal matter.



Orthopteran body parts recovered from faecal matter.

Karera is from mid March to end June. Although occasional nests were found in July and August as well, courtship display of adult males was not seen after June.

The other areas were Nanaj (for details see Ali and Rahmani 1982-84, Rahmani and Manakadan 1989) and Rollapadu (see Manakadan and Rahmani 1989).

Methods

Study plots: Seven plots where bustards were seen foraging were selected (Fig. 1). The names of these plots are based on local names. Detailed descriptions of the plots are given by Bhushan (1985) and Rahmani (1989).

Analysis of faecal samples: More than 300 faecal samples were collected at Karera for analysis to determine the bustard's varying dependence on seasonal food. Most of the samples were collected from roosting sites. Wet samples were preserved in 10% formalin, and dry samples preserved in separate packets for later analysis. Analysis was done on the basis of Korschgen (1969) and Lorin (1970). Faecal material was studied under a stereoscopic binocular microscope. Various items in the diet were identified by comparison with reference material or directly in the case of such undigested parts as chelicera (arachnida) , elytra and mandible (insects), seed (*Triticum*, *Zizyphus*) and pod (*Cicer*, *Arachis*).

Figs. 2 and 3 show the percentage weight of various food items in the faecal material collected fortnightly. Although insects appear to be preferred by the bustards (visual observations), they are under-represented in the figures, mainly because they were digested and thus did not show relative proportions in the faecal material. On the other hand, plant material is over-represented mainly because many plant parts (i.e. seed) remain undigested and are thus easily identified and weighed. Small reptiles which are opportunistically eaten (visual observations) were not recorded in the faecal material. These limitations should be kept in mind while interpreting figures.

Feeding rates: The bustards were observed while foraging by the scanning method, wherein the bird was watched continuously for a five minute unit, termed here as a 'scan'. During a single scan, each peck by the bustard away from its lateral position was counted. The total number of pecks in a single scan was considered to be the feeding rate (or peck rate) for that particular scan (after McKee 1982). The scan count was discontinued when the bird went out of view.

Peck rates were studied from May 1982 to August 1984 and 1271 readings were taken, spread over different seasons and months. For various reasons, equal number of readings could not be taken every month or every season. Most readings were taken during the breeding season (summer) and in winter, when the birds were watched more regularly.

Identification: To study the peck rate of different individuals, bustards were identified as (i) Alpha male = adult territorial male; (ii) Beta male = subadult non-territorial male; (iii) Juvenile male = less than one year old, generally seen with the mother; (iv) Mother = hen with juvenile; (v) Breeding female = hen with an egg or a chick; and (vi) Non-breeding female = hen without an egg or chick.

Entomological studies: Sweeping method was used to count the insect number. Weekly sweeps were carried out in different plots. 100 sweeps each were done over a fixed stretch of an area in each plot, between 0700 and 0900 hrs. The main emphasis was on the study of grasshoppers, which constitute the major animal food of the bustard, and are comparatively large and easy to identify and count. Moreover, sweeping method is much more effective to study the population of Orthoptera and Lepidoptera than Coleoptera. The insects caught or flushed during sweeping were counted.

The following were the common Orthopterans and Lepidopterans found in the study area: *Acrida exaltata, Chloeobora* sp., *Chrotogonus* spp., *Dnopherula* sp., *Gastrimargus africanus*, *Locusta migratoria*, *Pyrgomorpha* sp., *Spathosternum* sp., *Acorypha* spp., *Catantops* sp., *Chorthippus* sp., *Eyprepoenemis* sp., *Hieroglyphus* sp., *Patanga* sp., *Poicilorhynchus*

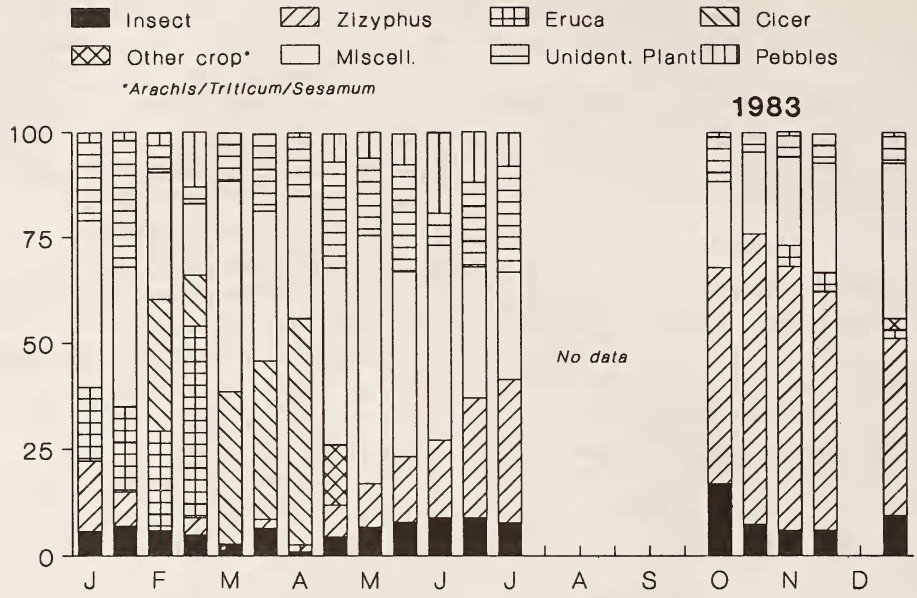


Fig. 2. Percentage of various food items in faecal samples of great Indian bustard collected in 1983.

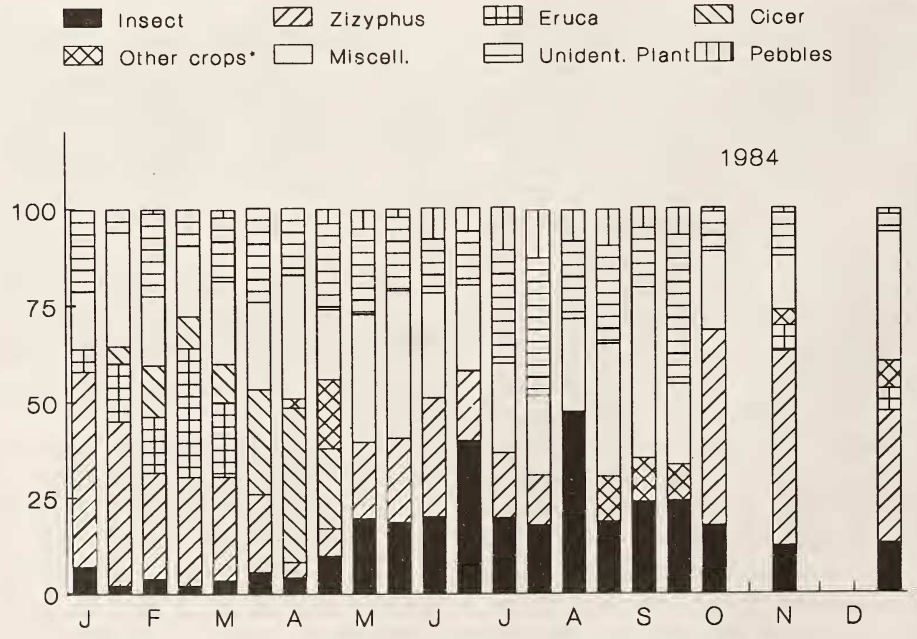


Fig. 3. Percentage of various food items in faecal samples of great Indian bustard collected in 1984.

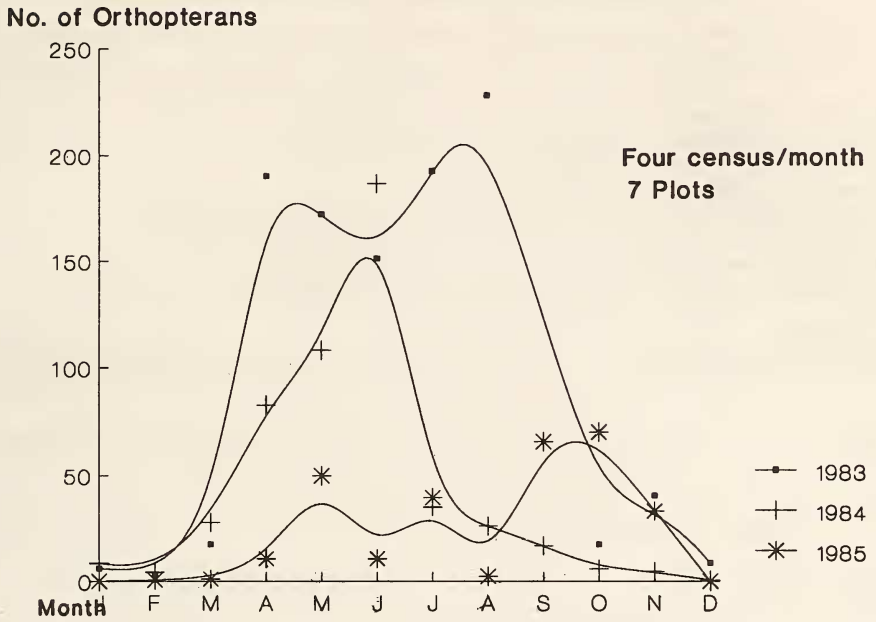


Fig. 4. Monthwise and inter-annual variation in numbers of Orthoptera in the study area.

pictus and *Sphingonotus* sp.; and *Tarucus indica*, *T. nara*, *T. theophrastus*, *Eurema brigitta*, *Precis lemonias*, *Precis orithyia*, *Papilio demoleus*, *Acraea violae*, *Hypolimnas misippus* and *Belenois mesentina*.

Though Coleopterans are commonly eaten by bustards (Ali and Ripley 1969, Bhushan 1985), they are mainly crepuscular or nocturnal, and are rarely caught in the sweep net. Pitfall traps (using petri-dishes filled with formalin to trap beetles) were not used in order to avoid accidental drinking of formalin by bustards and wild mammals. Moreover, there were always chances of petri-dishes being broken by grazing livestock or by blackbuck.

Five habitat types were selected for insect studies: (i) Open scrub; dominated by *Zizyphus rotundifolia* (average height 50 cm) and very low tree density (<1 tree/10 ha). (ii) Usar area; bare, alkaline area, dominated by *Chloris stricta* grass. (iii) Wooded scrub: dominated by *Z. rotundifolia* and *Acacia leucophloea* (tree density > 5/10 ha). (iv) Inside plantation; totally protected 20 ha forest plantation, dominated by various grasses (height >100 cm) and some trees (density >1 tree/10 ha). (v) Outside plantation: very similar to Open scrub, i.e. dominated by *Zizyphus rotundifolia*; this category was selected to compare the counts with the adjoining Plantation plot.

Results

Population fluctuation of Orthoptera and Lepidoptera: At Karera, the orthopteran population was very low during winter (October to February). From the middle of March, it starts rising and reaches its peak during the late summer or monsoon. Inter-annual variation was seen in population as well as in the timing of peaks and troughs (Fig. 4). These were also dependent on local factors such as precipitation and temperature.

The lepidopteran number, on the other hand, is generally low in late winter and summer, but soon after the monsoon breaks, it starts increasing and reaches its peak during August and September.

TABLE 1
LITERATURE REVIEW OF THE FOOD OF THE GREAT INDIAN BUSTARD

Food recorded	References
Insects	
"Grasshoppers, *Mylabris, Buprestris*, Scarabaei..."	Hume and Marshall 1879
"Grylli, beetles of all kinds (Cetonidae, Elateridae, Buprestidae, Carabidae), frequently the spongy nidus of the mantis, caterpillars, Julidae, Scolopendridae...."	Elliot 1880
"Locusts, grasshoppers, beetles, crickets, mole-crickets, ants"	Dharmakumarsinhji 1957
Green blister beetle *Cantharis tenuicollis*	Ali and Ripley 1969
Beetles (*Gymnopleurus?, Atactogaster*)	Gupta 1975
Curculionidae: *Platynotus, Mylabris, Sternocera nitidicollis*	Manakadan 1985
Scorpions, spiders etc.	
"Centipedes, spiders, scorpions, worms"	Hume and Marshall 1879, Elliot 1880, Dharmakumarsinhji 1957, Gupta 1975
Reptiles	
"Lizards, snakes..."	Hume and Marshall 1879, Dharmakumarsinhji 1957, Ali and Ripley 1969
Echis carinatus	Carter 1912
Uromastix hardwickii	Gupta 1975
Bird eggs	
Egg of *Coturnix*	Hume and Marshall 1879
Mammals	
Rats	Hume and Marshall 1879
Mice	Dharmakumarsinhji 1957
Plants*	
"green shoots of lemon grass *Citronella*"	Dharmakumarsinhji 1957
Carissa	Hume and Marshall 1879, Gupta 1975
Salvadora	Dharmakumarsinhji 1957
Inanimate matter	
"stones & gravel", "pebbles"	Hume and Marshall 1879, Elliot 1880, Dharmakumarsinhji 1957
"brass ornament"	Hume and Marshall 1879

*Plants included here are not listed in Table 2.

FOOD RECORDED THROUGH FAECAL ANALYSIS

SEASONAL VARIATION

Winter (October to February): Winter in Karera starts in October. Insect numbers start declining, and the monsoon crop such as groundnut *Arachis hypogea*, as well as *Zizyphus* drupes, start ripening. In the beginning of October, bustards were mainly seen feeding on insects and drupes of *Zizyphus*. By mid-October, the insect number declines rapidly and bustards feed more and more on the ripe drupes of *Zizyphus*. While insects constituted 13% of the diet (by weight) in the first fortnight of October 1983, in the second fortnight they declined to 7% (Fig. 2). On the other hand, the percentage of *Zizyphus* increased from 65 to 68%.

In November also, drupes of *Zizyphus* constitute the major food (Fig. 2). Soeha *Eruca sativa*, which is a dryland winter crop at Karera, is relished by bustards. So is groundnut; bustards are frequently seen in groundnut fields, foraging on exposed nuts. They do not dig up the plants. However, we did not obtain groundnut in faecal samples.

TABLE 2
PLANT SPECIES IDENTIFIED IN THE BUSTARD DIET

Family	Species	Remarks
CRUCIFERAE	*Eruca sativa*	Crop
	Brassica campestris	Crop
MALVACEAE	*Hibiscus abelmoschus*	Wild plant/weed
TILIACEAE	*Triumfetta rhomboides*	Wild plant
LINACEAE	*Linum usitatissimum*	Crop
RHAMNACEAE	*Zizyphus rotundifolia*	Wild plant
LEGUMINOSAE	*Cicer arietinum*	Crop
	Arachis hypogea	Crop
	Vigna sinensis	Crop
CUCURBITACEAE	*Cucumis melo*	Wild plant/weed
PEDALIACEAE	*Sesamum indicum*	Crop
GRAMINEAE	*Sorghum vulgare*	Crop
	Triticum vulgare	Crop

In December, the percentage of *Zizyphus* in the diet of bustards declined to less than 50% (Fig. 2), while the percentage of *Eruca sativa* did not change significantly. Similarly, there was not much change in the insect constituents. Vegetal matter remained the major part of the diet as indicated by the faecal samples.

Although *Zizyphus* drupes are more or less exhausted by January, bustards were still able to pick up sufficient numbers to constitute up to 51% by weight in the first fortnight of 1984 (Fig. 3). In both 1983 and 1984, in the second fortnight of January the percentage of *Eruca sativa* increased (Figs. 2, 3).

This is further corroborated by our visual observations in the field. The insect number was very low (Fig. 4) and hence bustards were more frequently seen in the crop fields of soeha and Bengal gram *Cicer arietinum*. Sometimes complete pods of gram were found in the droppings but we rarely saw them eating the pods of soeha. Occasionally, they were seen feeding on mustard *Brassica campestris* and til *Sesamum indicum*.

In the first fortnight of February, *Eruca sativa* constituted 14.7 and 23.4% in 1983 and 1984 respectively, while in the second fortnight it increased to 33.6 and 45.7% (Figs. 2, 3). Similarly, the percentage of Bengal gram also increased in the second fortnight. In 1983, we found very little *Zizyphus* in the faecal samples, unlike 1984 when in both the fortnights, *Zizyphus* constituted 28% (Fig. 3). This could be due to a sampling error. In 1983 only five samples were analysed in each fortnight while in 1984, 12 and 16 samples were studied, which showed the diet variation more clearly. In February, as in other winter months, insects formed less than 10% of the diet of the bustard (as shown by faecal sample analysis).

Summer (March to June): In early March, the Bengal gram and soeha start ripening but the bustards are still seen in the crop fields, picking up the late flowers of soeha and unripe pods of Bengal gram. Insects start increasing in number (Fig. 4) but still formed less than 10% in the faecal samples analysed by us (Figs. 2, 3).

By the third week of March, when harvesting of early-grown wheat begins, bustards can be seen in newly harvested wheat fields, picking up the fallen grains. Soeha is also harvested by the fourth week of March, after which bustards are rarely seen in soeha fields. Breeding of bustards at Karera starts from the middle of March (Rahmani 1989). During the first fortnight of April Bengal gram is the main standing crop eaten by bustards at Karera, and constituted nearly 50% of the diet. Its percentage declined during the second fortnight (Figs. 2, 3). At the same time the percentage of wheat increased in faecal samples as more fields are harvested. By the third week of April all wheat fields are harvested and livestock grazed on crop residue.

With the approach of summer and rise in temperature, small reptiles come out of hibernation and the population of *Sitana ponticeriana*, *Agama minor*, *Mabuya* spp., *Ophisops jerdonii* and *Calotes versicolor* increases. *Sitana*, *Ophisops* and *Agama* are easily caught by foraging bustards because these small lizards generally depend on camouflage, remaining immobile when danger threatens. We often saw bustards with small lizards, but rarely saw them catching *Calotes versicolor* which is mainly arboreal. An injured *Calotes* offered to our captive-cum-free ranging juvenile bustard at Rollapadu was not eaten by it (Manakadan and Rahmani 1990). However, we suspect that an adult bustard can easily eat a *Calotes* because we have seen them eating snakes, sometimes larger than an adult *Calotes*.

During May and June there is hardly any crop at Karera and bustards depend totally on natural food (Figs. 2, 3). Insects, especially Orthopterans, reach maximum numbers, and form the main food, though this is not reflected in faecal analysis for reasons stated earlier (Fig. 4).

Monsoon (July to September): With the onset of the monsoon in end June or early July, agricultural activities begin and millet, pennisetum, sesamum and groundnut are grown. Insect numbers remain high and constitute nearly 10% of the diet of the bustard (as indicated by faecal samples, though it must be higher) (Fig. 2). In August 1984 (we have no data for August 1983), insects constituted 47.31% in the first fortnight and 18.52% in the second fortnight (Fig. 3).

Bustards also feed on *Cucumis melo* var. *momordicum*. Locally known as 'gila', the cucumber-like *Cucumis melo* is locally considered as a weed and grows naturally in groundnut fields. Bustards feed on the fruit (3-5 cm long and 2-3 cm broad), and presumably digest the entire fleshy matter and possibly the unripe seeds also, because only the hard seeds were found in faecal samples.

During September, insects constituted about 20% of the diet (Fig. 3). Groundnut is a new crop which is added to the food of the bustard from this month onward till it is harvested in November/early December. Bustards are first seen in the groundnut fields when it is sown, and later when it is ready for harvesting. As the groundnut plant is very short (20-30 cm), it is suitable for bustards and the birds are regularly seen there.

By the end of September, monsoon crops are harvested and fields are prepared for winter crops such as wheat, soeha and Bengal gram. The insect numbers start declining. At the same time, drupes of *Zizyphus* start ripening and more bustards are seen picking the drupes from bushes. The cycle repeats itself.

Crop Plants Eaten by Bustards

Soeha: Soeha or taramira is a dry-land winter crop extensively grown in Karera and the whole of north-west India. We have seen it grown in Sorsan, Sonkhaliya (Rajasthan), Ghatigaon and Pohri (Madhya Pradesh) bustard areas/sanctuaries. The whole plant – inflorescence, leaves and shoots – is eaten by bustards. As long as there are flowers and fresh green leaves, bustards are seen in soeha fields. Some of the highest peck rates were found in the soeha fields (see Table 3).

Soeha is a marginal crop, grown only in those areas where irrigation facilities are scanty. If a field can be irrigated, farmers prefer to grow more commercially profitable crops.

Bengal gram: After soeha, Bengal gram *Cicer arietinum* is the most preferred crop of bustards at Karera. Cool dry climate and light well-drained soil are essential for successful cultivation. It can be grown with or without irrigation. The plant is 30-40 cm tall and is grown in narrow rows. At Karera, it is mainly grown in non-irrigated or marginally irrigated areas. Sometimes it is grown with wheat.

Bustards eat young shoots, flowers and unripe pods of Bengal gram. The highest peck rates were observed in Bengal gram fields (Table 3). If undisturbed, they visit the same gram fields over consecutive days. We have recorded stems, leaves, seeds and pods in the faecal samples.

Occasionally, an entire pod with seeds within was recovered in the droppings.

Groundnut: This is one of the most important commercial crops of Karera and in almost all the bustard areas (except the Thar desert). It is grown mainly as a monsoonal crop, sown at the start of the monsoon and harvested in October/November. As groundnut is favoured by bustards, their presence can be predicted in a particular field. Soon after the water has dried from a freshly irrigated groundnut field, bustards visit the field to pick up nuts that have been exposed by the flow of water. Similarly, they are seen for many days in a newly harvested field where some nuts are left behind. The birds move from one harvested field to another, consuming the scattered nuts. We were able to bait bustards during summer by spreading wheat and groundnuts in areas frequented by bustards. An interesting behaviour seen from the hide was that the bustards shake the nuts before eating; spoiled nuts, which possibly do not produce the characteristic rattling sound, were discarded.

Wheat: We never saw any bustard eating wheat *Triticum vulgare* from the spike in a standing wheat field. They were mainly seen as soon as the wheat was harvested, picking up the fallen grains. On a few occasions we also saw them picking up fallen grains from cart-tracks after wheat-laden carts had passed by. Wheat was another food item by which we were able to attract bustards at Karera.

Incidentally, bustards at Nanaj were not attracted to wheat when we tried to catch them for colour banding. Similarly, at Karera, we were unable to attract bustards to wheat bait after the onset of the monsoon. This could be due to two major reasons: (i) during monsoon bustards get sufficient food in their natural habitat, and so are not particularly attracted to wheat, and (ii) damp soil quickly spoils the grain which bustards do not eat.

Millet: Unlike wheat, bustards were found to eat millet (jowar) *Sorghum vulgare* from the standing crop plants. At Nanaj, many bustard droppings had millet seeds, and on a few occasions we saw bustards pecking at spikes of millet.

Mustard: Although closely related to soeha, mustard *Brassica campestris* is not a preferred food of the bustard. Only once was a male found eating green leaves from standing plants. It is commonly grown at Karera, Pohri, Ghatigaon, Sonkhaliya and the whole of north-west India, either alone or with wheat or sesame.

Cowpea: Twice we saw a male bustard eating the beans of cowpea *Vigna sinensis*. However, cowpea was never found in faecal samples.

Linseed *Linum usitatissimum:* This crop is commonly grown along with soeha and Bengal gram. Although we did not see the bustard feeding on this plant, seeds were recorded in the faeces..

Peck Rate

Feeding or peck rate (PR) per five minutes was analysed with a combination of various other parameters.

Sex-wise peck rate: The average peck rates (PR) of male and female bustards in the Open scrub area were significantly different (One-way ANOVA, $F_{1,1019} = 4.33$, $P < 0.05$). Males had a higher PR than females.

Habitat-wise peck rate: (Table 3) The maximum number of observations were taken in the Open scrub area (n = 1028, 80%). More than 80% of the natural area of the Sanctuary consists of *Zizyphus rotundifolia*-dominated scrubland.

Fallow fields are quickly invaded by *Zizyphus* and within two or three years become almost like the Open scrub area. In both Open scrub area and fallow fields, livestock grazing is allowed.

Expectedly, there was not much difference in the PR between these two similar habitats (Table 3). Some fallow fields in which livestock grazing is not allowed, become dominated by grasses. We have considered them as grassland. The PR was slightly higher in Grassland than in Open scrub area or fallow fields (Table 3). This could be due to the higher number of insects in the grassland. Unfortunately, our sample size is very small (only 12 observations). This was mainly because

TABLE 3
AVERAGE PECK RATES OF BUSTARDS IN DIFFERENT HABITATS

Habitat	Mean	SD	No. of samples
Chana (Bengal gram)	67.40	37.29	40
Soeha	46.48	28.00	93
Miscellaneous crops	41.22	36.36	28
Groundnut	15.33	3.77	6*
Grassland	13.91	4.75	12*
Open Scrub	12.09	10.23	1028
Fallow field	10.87	4.34	56
Usar area	3.87	2.89	8*

*Sample too small for statistical analysis n = 1271.

grassland patches in Karera are small and temporary. As soon as the grass becomes tall, it is either cut for hay or grazed.

The Usar is more or less totally bare ground with negligible ground cover. In the Usar, the peck rate was also very low (3.87, n = 8). The Usar was rarely used for foraging, hence the low sample size. We saw bustards in the Usar when they were crossing from one Open scrub area to another.

Among the crop fields, Bengal gram had the highest peck rate (Table 3). This is probably because the plants are only about 30 cm high, and when ripe, the green pods are easily picked by bustards. As the plant is grown closely in narrow rows, the bird does not have to move much and from one or two spots, it can pick up a large number of pods. Moreover, we have also seen bustards plucking the green leaves of chana (which does not require much effort); hence the very high PR in chana fields.

We recorded bustards in chana fields in October and December, though faecal analyses do not show presence of chana in these fortnights. The bustards must have fed on tender shoots that were easily digested or were not identifiable in faecal analysis.

The second highest peck counts, after chana fields, were seen in the soeha field (Table 3). Here too, the bustard does not have to move much or search for food once it is in a soeha field. We have often seen bustards eating the whole plant, starting from inflorescence, leaves, tender branches to the green part of the stem.

In groundnut fields, the bustard has to search for exposed pods. This could explain the PR of 15, compared to 46 and 67 in other crop fields (Table 3). Another explanation could be that groundnut pods being much bigger (and perhaps more nutritious) than chana pods and leaves and flowers of soeha, the bustard has to peck less to get the same amount of food.

Plot-wise peck rate: The plot-wise PR is shown in Table 4. In order to study the availability of natural food in different parts of the Sanctuary, we analysed the PR in the Open scrub areas of different plots (Table 4) and found no significant difference (One-way ANOVA, $F_{6,975} = 0.017$, NS).

Peck rates of different individuals: There was no significant difference in the PR of Alpha and Beta males or Alpha and Juvenile males (Tables 5, 6). Similarly, there was no significant difference between Mother and Juvenile which foraged together in the same areas. The only significant difference in the PR was between Breeding hens and other individuals such as Non-Breeding hens, Mother, Alpha and Beta.

Peck rates of solitary and non-solitary birds: We compared the PR of the solitary and non-solitary bustards in the Open scrub areas (Table 7), where the bustards spent most of their time. There was no difference in PR between solitary and non-solitary hens ($t = -0.29$, St. Err. = 2.11, Df = 437, NS) and very little difference between solitary and non-solitary males ($t = -1.76$, St. Err. = 0.67, Df = 587, $P < 0.1$). This shows

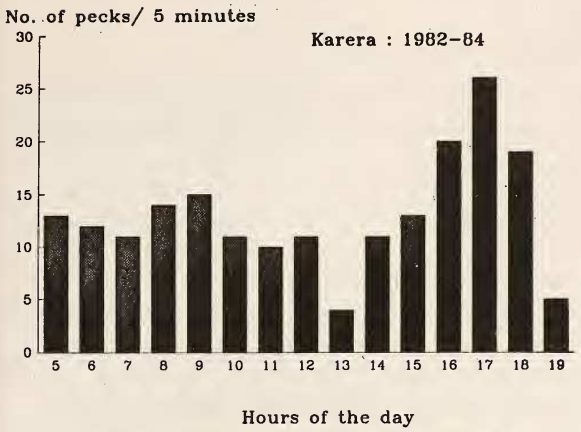


Fig. 5. Feeding intensity in the great Indian bustard at Karera.

that even when the bustard is in a flock, it feeds more or less individually.

Peck rates at different hours: Peck rates were higher in the late morning, and in the evening before roosting (Fig. 5). This could be because before roosting the birds have to eat sufficient food, so they peck faster before conditions become difficult for foraging. Maximum peck rates were observed in the evening. An additional reason for the high peck rate in the late evening could be that in the evening most of the villagers and livestock would return to villages; therefore bustards are left relatively undisturbed to forage, and could devote more time to eating (pecking). Expectedly, the peck rates drop suddenly after 1800 hrs because the birds are not able to locate their prey easily after dusk. At this time, most of the bustards roam in search of roosting spots and eat desultorily. With the approach of nightfall, risk of predation increases, so the birds spend more time looking for danger and less on foraging.

Minimum peck rates were seen during mid-day (Fig. 5), especially during summer when the temperature can reach 48° C. Mid-day foraging was seen more frequently in winter or during cloudy days in the monsoon.

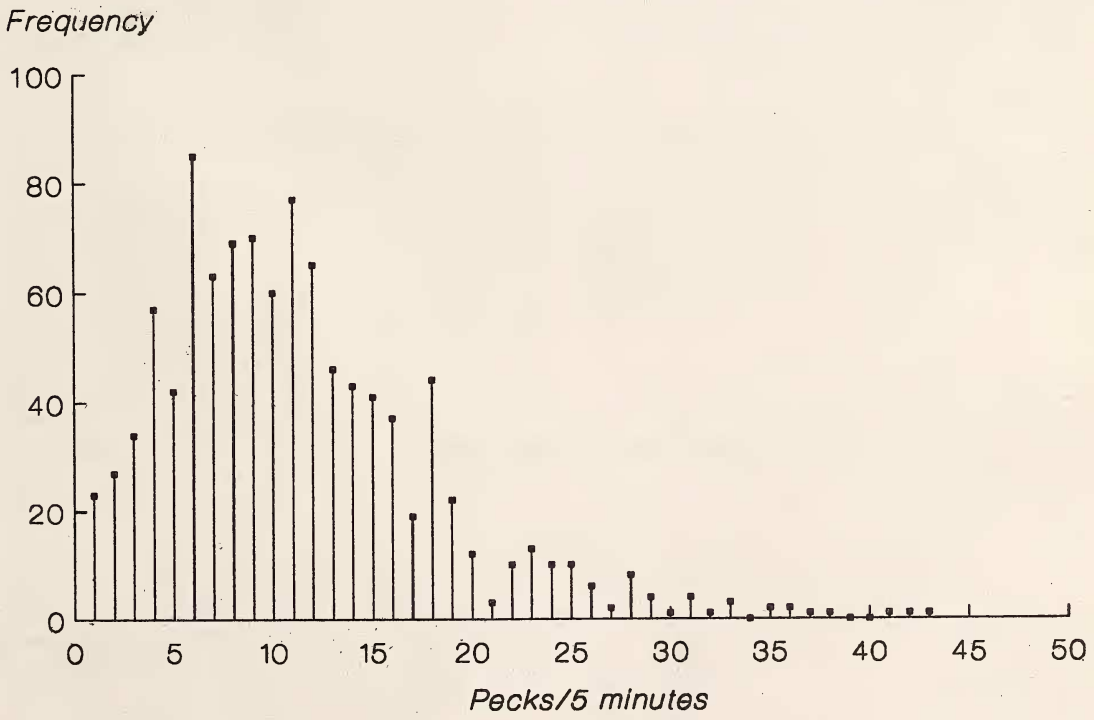


Fig. 6. Frequency distribution of peck rate in the great Indian bustard at Karera.

TABLE 4
PECK RATES IN THE OPEN SCRUB AREAS OF DIFFERENT PLOTS

Name of the Plot	Mean	SD	No. of samples
Turkani	11.14	7.35	416
Hanuman-jhoora	12.38	8.20	31
Rasori	10.95	6.22	252
Kundpatha	10.54	6.62	133
Karawwa	11.31	4.89	94
Outside Plantation	8.18	2.79	11
Baigawan	12.57	7.66	45

TABLE 5
PECK RATES OF DIFFERENT SEXES AND DIFFERENT INDIVIDUALS IN OPEN SCRUB AREAS ONLY

Sex/Individuals	Mean	SD	No. of samples
Sex			
Male	11.5	7.05	589
Female	10.6	6.41	433
Individuals			
Alpha male	12.11	7.14	288
Beta male	11.89	7.46	167
Juvenile male	9.97	5.01	109
Mother (with juvenile)	12.44	7.36	98
Breeding hen	6.69	2.71	59

TABLE 6
SCHEFFE'S TEST TO FIND THE SIGNIFICANCE BETWEEN VARIATIONS IN PECK RATE IN DIFFERENT SEXES AND DIFFERENT INDIVIDUALS

	NBF	MOF	BF	ALM	BEM	JUM
NBF	0.00	4.41	18.84*	5.51	2.77	1.25
MOF		0.00	27.83*	0.18	0.43	7.19
BF			0.00	32.95*	26.92*	9.42
ALM				0.00	0.13	8.31
BEM					0.00	5.53
JUM						0.00

*$P < 0.01$
NBF = Non-breeding female, MOF = Female with chick, BF = Breeding female, ALM = Alpha male, BEM = Beta male, JUM = Juvenile male.

TABLE 7
PECK RATE OF SOLITARY AND NON-SOLITARY BIRDS IN THE OPEN SCRUB

Sex	Mean	SD	No. of samples
Solitary female	12.78	8.84	194
Non-solitary female	12.17	6.12	245
Solitary male	12.30	8.76	272
Non-solitary male	11.12	7.15	317